A SURGICAL PROTOCOL FOR COMBINED INTERNAL AND EXTERNAL FIXATION OF COMPLEX INTRAARTICULAR DISTAL RADIUS FRACTURES USING DORSAL AND VOLAR APPROACHES

Peter J. L. Jebson, M.D.
William F. Blair, M.D.

BACKGROUND

The majority of distal radius fractures are stable and amenable to closed treatment methods. Unstable fractures with intra-articular displacement require an alternative approach. This concept has become increasingly apparent since Knirk and Jupiter demonstrated that accurate restoration of the articular surface of the distal radius is the most critical factor in achieving a successful outcome[6]. Restoration of the articular surface can be accomplished with either internal or external fixation methods[1,3,5,7,8]. However, not all intra-articular fractures of the distal radius are amenable to treatment with one method alone. There is a subset of complex high energy fractures that appear to be best treated by a combination of internal and external fixation. This is presumably necessary because of increased fracture comminution and displacement, and the inability to achieve and maintain a satisfactory reduction with one method alone. In 1989, such a strategy was developed by the senior author. This strategy has been used prospectively with successful results[2]. The strategy features internal fixation performed through dorsal and volar approaches in addition to external fixation used for neutralization. The purpose of this paper is to describe in detail the technical features of the protocol using an illustrative case example. The strict methodical nature of the protocol is extremely helpful in reconstructing these complex, challenging injuries.

The primary indication for this strategy is the AO-C3 type injury, a severe intra-articular fracture with dorsal and volar metaphyseal comminution (Figure 1). The classification is based primarily on the appearance of the fracture on initial and post-reduction radiographs. Tomograms and computerized tomography, if obtained to better delineate the fracture pattern, can also assist with classification. The presence of associated carpal bone fractures, dislocations, or fracture-dislocations are not considered contraindications. Furthermore, the combined dorsal and volar approaches should not be used in those fractures where either approach alone could be successfully used; namely, B2, C1 and C2, or C3 type fractures where the dorsal or volar fragments are non or minimally displaced.

Address Correspondence to:
Peter J.L. Jebson, M.D., Department of Orthopaedic Surgery, University of Iowa Hospitals and Clinics, Iowa City, IA 52242-1009, Tel: (319) 353-7840

SURGICAL TECHNIQUE

The procedure is performed under a general anesthetic. The injured upper extremity and contralateral iliac crest are prepped and draped. The extremity is exsanguinated

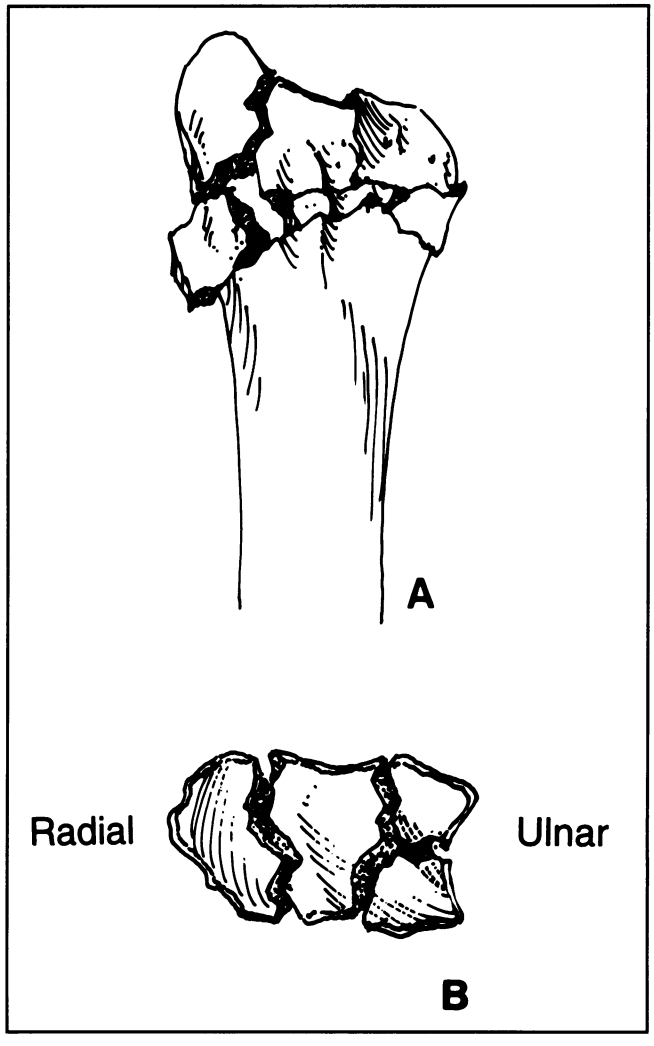

Figure 1. AO - C3 fracture of the distal radius in (a) coronal and (b) axial planes.

and the under tourniquet control, a dorsal longitudinal skin incision is made, centered over Lister's tubercle. The third dorsal wrist compartment is entered and the extensor pollicis longus (EPL) tendon is retracted radially. The distal radius is then exposed subperiosteally in a radial and ulnar direction. Care should be taken during subperiosteal dissection of the fourth compartment to avoid detaching the triangular fibrocartilage complex (TFCC). The proximal aspect of the radial styloid fragment must be completely exposed using subperiosteal elevation. Preliminary identification of the dorsal fracture pattern is performed after the fracture hematoma is evacuated. An attempt should be made to preserve any soft tissue attachments to all fragments. If free fragments are present, their position is noted and they are temporarily removed and preserved in lactated Ringer's solution. A moist sponge is then placed in the wound and the forearm is gently fully supinated.

The volar approach is performed through the flexor carpi radialis (FCR) sheath. The pronator quadratus is exposed and the distal radial corner is sharply released. The pronator is elevated subperiosteally and retracted proximally and ulnarly. All volar fragments are mobilized and the overall fracture pattern identified in relation to the dorsal fragments. A volar capsulotomy is not performed so the integrity of the extrinsic radiocarpal ligaments can be preserved.

The Dynafix distal radius external fixator (EBI Medical Systems, Parsippany, NJ) (Figure 2) is then applied to the second metacarpal and radial shaft using a limited open technique. The second metacarpal is initially exposed via a longitudinal incision beginning at the metacarpal base and extending distally three centimeters. The second metacarpal shaft is exposed bluntly. The hand held drill guide is positioned over the metacarpal at a 45° angle with respect to the plane of the palm and perpendicular to the metacarpal shaft. The drill sleeve is inserted and the proximal hole drilled first, while lifting the guide slightly away from the bone to observe the drill engaging the center of the metacarpal. The first 70/20 screw is placed by hand through both cortices using the T-handled wrench. The drill guide is placed over the first screw, the drill sleeve inserted, and a second, more distal hole is similarly drilled. The second screw is then placed. The fixator is tentatively positioned on the metacarpal screws in a preset shortened configuration. The anticipated location of the incision for placement of the proximal screws is marked through the proximal clamp. This should be planned so that the screws will be proximal to the fracture. A longitudinal incision is made in the dorsoradial forearm and the antebrachial fascia exposed bluntly. The superficial radial nerve is identified, mobilized and protected. The radial shaft is exposed between the wrist extensors and brachioradialis. The proximal 80/30 screws are placed in the radius in a similar manner. Screw lengths are assessed with fluoroscopy. Screws that have not penetrated the opposite cortex are advanced until one thread is beyond the far cortex. Because the bone screws are tapered, 'long' screws should not be backed out. The incisions are then closed with interrupted 5-0 nylon sutures. Any tension in the skin around the screws is released. The Dynafix frame is then applied placing the short bar distally and the C-frame dorsally (Figure 2). If the C-frame is not centered over the fracture, the site of the screw clamps on the bar may need adjusting. Reduction of the fracture is then performed.

Alignment of the hand relative to the forearm is fundamental to achieving a satisfactory reduction; it is accomplished using a specific reduction maneuver. Firm longitu-

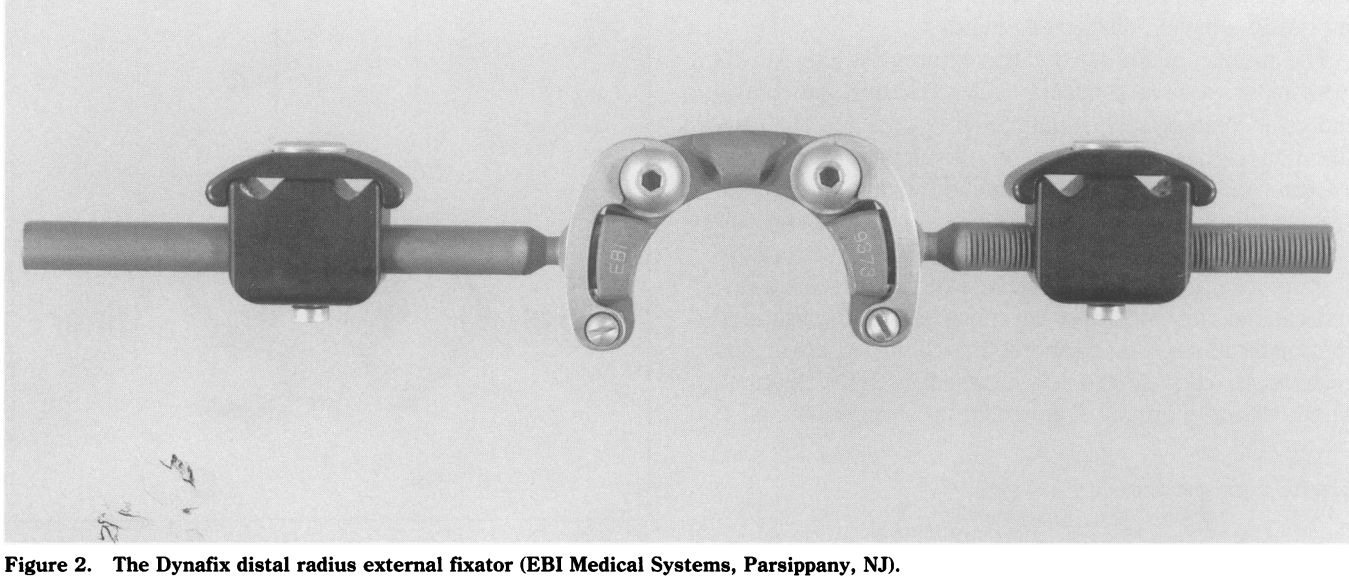

Figure 2. The Dynafix distal radius external fixator (EBI Medical Systems, Parsippany, NJ).

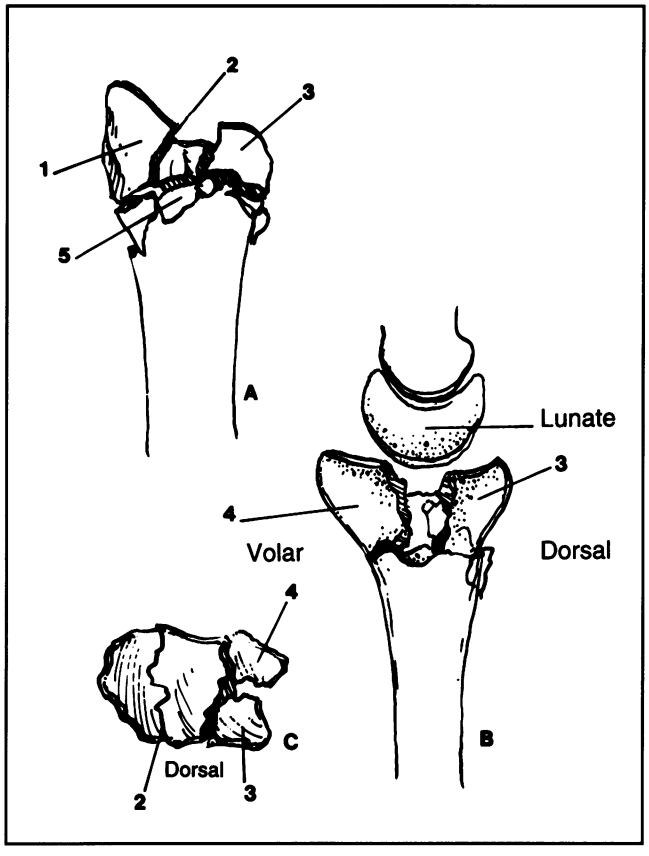

Figure 3. Schematic representation of an AO C type 3.2 distal radius fracture in the (a) coronal (b) sagittal and (c) axial planes. Note the (1) radial styloid fragment, (2) fracture line dividing the scaphoid fossa, (3) lunate fossa 'die punch' fragment, (4) volar lunate fossa fragment, and (5) dorsal metaphyseal comminution.

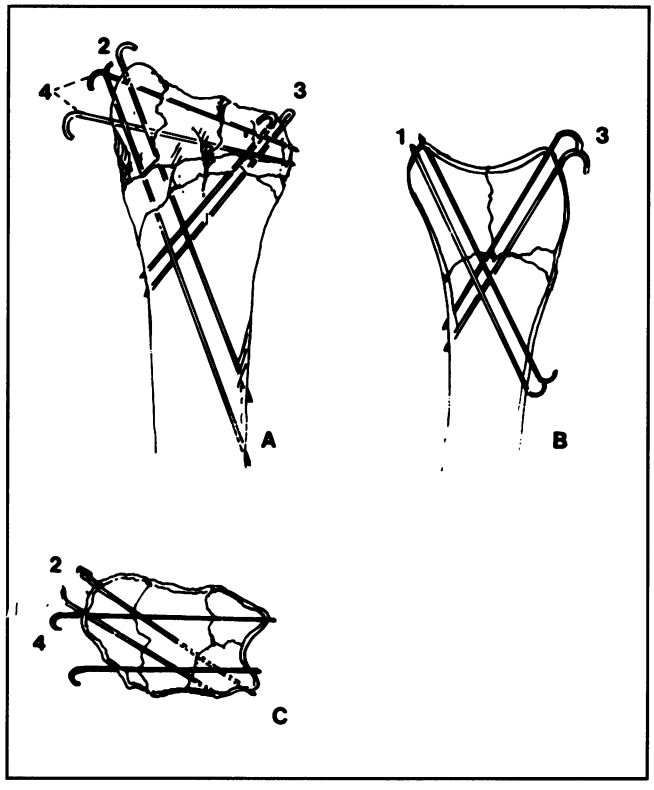

Figure 4. The fixation sequence of the AO C type 3.2 fracture shown in Figure 3. Reconstruction of the fracture is begun volarly in a proximal to distal direction (Figure 4B). The preferred sequence for Kirschner wire placement is numbered in order and demonstrated in the accompanying illustrations (Figures 4A and C).

dinal traction through the index and long fingers is applied with the elbow secured. The ulnar aspect of the wrist is supported and when proper alignment and rotation of the hand relative to the forearm is obtained, the fixator is locked into place. Posteroanterior (PA) and lateral fluoroscopic images of the wrist are obtained. Confirmation of optimum alignment of the hand relative to the forearm is critical. The axes of the radius, lunate, and capitate must be colinear in both views before proceeding to reconstruction of the fracture. The degree of restoration of radial length, inclination, and palmar tilt, as well as congruence of the radiocarpal and distal radioulnar joints should be assessed[4].

Fluoroscopic images should be scrutinized for any carpal injuries. If a carpal fracture or ligamentous injury is identified, distraction across the wrist is released, and the carpal injury is treated.

A dorsal transverse capsular incision is then made just distal to the dorsal radial lip of selected fragments to better visualize the distal radius articular surface. The capsular incision is extended longitudinally and distally along the axis of the lunate, thus creating an inverted T-shaped capsulotomy. The carpus is inspected for fracture and chondral or ligamentous injuries. Gentle distraction is then applied and the sequence of reduction, fixator tightening and radiographic assessment repeated.

Reconstruction of the fracture is performed under direct visualization through both incisions. Anatomic reduction is usually accomplished by reducing and fixing the fragments in a proximal to distal and volar to dorsal sequence. We prefer to use smooth Kirschner wires for fixation but neutralization plates or interfragmentary screws are appropriate for selected fracture patterns.

The volar fragments are reduced first and secured to the radial shaft with Kirschner wires drilled in a distal volar to proximal dorsal direction (Figure 4B). The wires are advanced through the dorsal skin and then backed out dorsally until the tips are left just penetrating the volar cortex. Wire placement into the area of dorsal metaphyseal comminution or the extensor tendons must be avoided. Reconstruction is then continued dorsally. The radial styloid fragment is reduced and secured to the shaft by two wires inserted percutaneously (Figures 4A and C). The articular surface is then reassembled and stabilized via dorsal to volar and/or radial to ulnar directed wires placed directly or percutaneously (Figures 4A and B). The wires

may stabilize the reduced fragments by engaging them directly or by acting in a buttress mode beneath, or adjacent to, the anatomically reduced fragments. Rarely, wires can be placed through the fragments and into the carpus to achieve fixation if necessary. The construct is then assessed on PA and lateral fluoroscopic images. The previously mentioned anatomic parameters, wire positions, and wire lengths are checked. The wires are cut and bent above the skin. Extensive metaphyseal bone loss is invariable, and cancellous bone grafting from the iliac crest is usually required. Adequate cancellous graft can usually be obtained using coring instrumentation. The dorsal capsulotomy is closed with nonabsorbable suture in an interrupted figure-of-eight fashion. The extensor retinaculum is closed beneath the EPL tendon. The pronator quadratus is sutured to the lateral margin of the radius with a nonabsorbable suture whenever possible. The tourniquet is deflated and hemostasis is obtained prior to skin closure. Drains are placed if necessary and a compressive dressing is applied.

POSTOPERATIVE TREATMENT AND REHABILITATION

The extremity is elevated, and aggressive active and passive digital range of motion and daily pin care are initiated on the first postoperative day. The skin sutures are removed at two weeks, at which time full active index finger range of motion should be verified. The goal is full active range of motion of all fingers within three weeks of the operation. In general, Kirschner wires used for distal radius fracture fixation are removed 6-8 weeks postoperatively. Wires used for carpal fractures or ligamentous injuries are removed 8-10 weeks postoperatively. If radiographs confirm consolidation of the fracture and graft at 10-12 weeks, the external fixator is removed and a volar forearm based thermoplastic splint is fashioned. The patient is instructed in a supervised progressive wrist range of motion and strengthening program.

COMMENTARY

The preliminary results of this treatment strategy for AO-C3 fractures of the distal radius have been reported by the senior author (WB)[2]. The co-author of this paper is gaining considerable experience with this protocol and has found the strict methodical nature of the protocol to be extremely helpful in reconstructing these complex, challenging injuries.

REFERENCES

1. Axelrod, T.S. and McMurtry, R.Y.: Open reduction and internal fixation of comminuted intra-articular fractures of the distal radius. *J. Hand Surg.*, 15A:1-11, 1990.
2. Bass, R.L.; Blair, W.F.; Hubbard, P.P.: Results of combined internal and external fixation for the treatment of severe AO-C3 fractures of the distal radius. *J. Hand Surg.*, 20A:373-381, 1995.
3. Bradway, J.K.; Amadio, P.C.; Cooney, W.P.: Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J. Bone Joint Surg.*, 71A(6): 839-847, 1989.
4. Gilula, L.A.: Carpal injuries: analytic approach and case exercise. *AJR*, 133:503-517, 1979.
5. Jakim, I. and Pieterse, H.S.: External fixation for intra-articular fractures of the distal radius. *J. Bone Joint Surg.*, 73B(2):302-306, 1991.
6. Knirk, J.L. and Jupiter, J.B.: Intra-articular fractures of the distal end of the radius in young adults. *J. Bone Joint Surg.*, 68A(5):647-659, 1986.
7. Missakian, M.L.; Cooney, W.P.; Amadio, P.C.; Glidewell, H.L.: Open reduction and internal fixation for distal radius fractures. *J. Hand Surg.*, 17A:745-755, 1992.
8. Seitz, W.H.; Froimson, A.I.; Leb, R.; Shapiro, J.D.: Augmented external fixation of unstable distal radius fractures. *J. Hand Surg.*, 16A:1010-1016, 1991.